

RADIOACTIVE WASTE MANAGEMENT IN REP. OF KOREA

1. NATIONAL FRAMEWORK FOR MANAGEMENT AND REGULATION OF RADIOACTIVE WASTE AND DECOMMISSIONING

1.1 National framework

1.1.1 *Overview of national policy*

The Atomic Energy Commission (AEC) of the Korean government developed the “National Radioactive Waste Management Policy” at the 249th meeting held on September 30, 1998. The policy stipulates that the site selection process for radioactive waste repository shall be managed transparently, and the government shall explain to the public about its plan to secure safety during site selection process. The summary of the national policy statements includes the following.

1) Direct control by the government

Radioactive waste, which needs a long-term safe management, shall be managed under the responsibility of the government.

2) Top priority given to safety

Radioactive waste shall be safely managed in consideration of biological and environmental impact so as to protect people, society and the environment from the harmful effects of radiation and to observe international norms on the safety of radioactive waste management.

3) Minimization of radioactive waste generation

Radioactive waste generation shall be minimized.

4) “Polluter pays” principle

The expenses related to radioactive waste management shall be levied on the radioactive waste generator at the point of radioactive waste generation, without imposing undue burden on future generations.

5) Transparency of site selection process

Radioactive waste shall be managed transparently and openly, and the radioactive waste management project shall be promoted in harmony with the local community, and community development.

1.1.2 *Overview of relevant institutions*

The governmental organizations concerned with nuclear activities, as shown in Figure 1.1, are mainly formed of administrative authorities; the Ministry of Knowledge Economy (MKE) supervises the nuclear power program, the Ministry of Environment (MOE) is responsible for regulating issues on the general

environment excluding the radiological environment, and the Ministry of Education, Science and Technology (MEST) is responsible for nuclear safety regulations including the licensing of nuclear facilities.

There is also the Atomic Energy Committee (AEC) under the jurisdiction of the Prime Minister, as the supreme organization for decision-making on national nuclear policies. And the Nuclear Safety Commission (NSC) under the jurisdiction of the MEST is responsible for the deliberation and decision on important matters concerning the safety of nuclear facilities and radioactive waste management.

Nuclear safety regulatory organizations are mainly composed of the MEST and the NSC as safety regulatory authorities, and the Korea Institute of Safety(KINS) as an expert organization of nuclear safety regulation. The MEST established the Nuclear Emergency Division in the Atomic Energy Bureau (AEB) in 2001, and the Off-site Emergency Management Center was established to direct nuclear emergency cases of nuclear sites, especially NPP in 2003. In 2006, the Korea Institute of Nuclear Nonproliferation And Control (KINAC) was established as an expert organization for the physical protection, safeguard of nuclear facilities including nuclear materials and for the control of export and import.

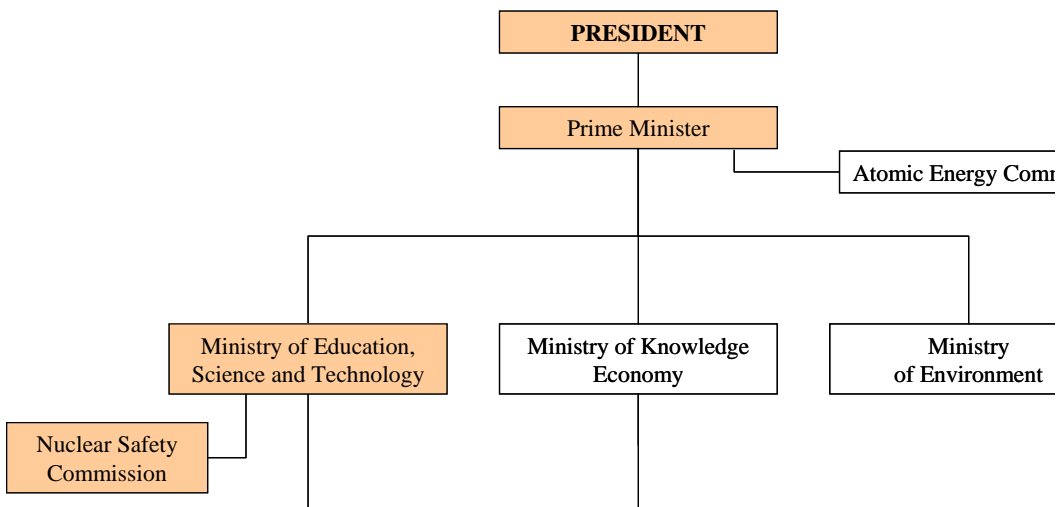


Figure 1-1 Governmental organizations related to radioactive waste management

1.2 Technical regulatory organisation(s)

1.2.1 Regulatory function

The MEST assumes responsibility to developing the licensing criteria for the construction and operation of radioactive waste disposal facilities, to develop technical standards for operational safety measures, and to secure radioactive waste safety management at every stage of the site selection, design, construction,

operation, closure, and post-closure of radioactive waste disposal facilities

1.2.2 Organisation and resources

The NSC, under the jurisdiction of the MEST, is responsible for deliberating and making decision on important matters concerning nuclear safety. The 2nd Vice Minister and the Director General in charge of the Atomic Energy Bureau(AEB) are in a vertical arrangement under the Minister.

The NSC organized the Special Committee on Nuclear Safety to technically investigate and deliberate matters under its jurisdiction. This Committee is divided into 5 Subcommittees(the Reactor System Subcommittee, the Radiation Protection Subcommittee, the Nuclear Emergency and Environment Subcommittee, the Site and Structure Subcommittee, and the Regulatory Policy Subcommittee). The NSC may also organize and operate the Special Investigation Committee if any nuclear and/or radiation accidents occur.

The KINS was established in December 1981, and initially operated under the name of the “Nuclear Safety Center” as an internal organization of the KAERI. It started functioning as an independent expert organization in February 1990, according to the “Korea Institute of Nuclear Safety Act,” and conducts works on nuclear safety regulation entrusted by the MEST in accordance with the Atomic Energy Laws. The KINS takes responsibility for activities such as the development of nuclear safety regulation technology, technical support to the MEST for policy development and radiation protection, information management on safety regulations, and the monitoring and evaluation of environmental radioactivity. The KINS consists of 2 departments , 6 divisions, 1 school and 38 sections, and operates the Advisory Committee on Nuclear Safety, a consultative body for technical matters on safety regulations, which is composed of experts from the KINS and other external organizations.

As of the end of May 2008, the KINS has a total of 386 staff members, of which 332 members are technical experts. To share its safety regulation technology and experience with the international community, the KINS opened the International Nuclear Safety School in January 2008, which has also functioned as the IAEA’s Asian training center since its conclusion of a Nuclear Safety Cooperation Agreement with the IAEA.

The safety regulation of radioactive waste management facilities is under the responsibility of the “Radiation and Waste Safety Division” in the KINS. The budget of the KINS, a sole expert organization of nuclear safety regulation, is mainly financed by the government and partially appropriated by regulation fees from licensees.

The KINS has concluded agreements with China, Germany, France, Japan, Romania, Spain, Sweden, UK, and USA for bilateral cooperation in radiological emergency preparedness as well as strengthening the sharing of techniques and knowledge of nuclear safety regulation through international collaboration with regulatory agencies in the cited countries.

1.3 National implementing organisations

1.3.1 Scope of responsibility

According to the 249th meeting of the AEC, the Government of the Republic of Korea adopted the nation’s ultimate responsibility for radioactive waste management in the light of the importance that long-term safe management of these wastes is required. . Based upon this principle, the MKE carries out the management policies on radioactive waste treatment, storage, and disposal, which are prepared by the MKE in consultation with the MEST and deliberated by the AEC.

According to the “Nuclear Safety Policy Statement”, the ultimate responsibility for the safety of a nuclear installation rests with the operating organization and is in no way diluted by the separate activities and responsibilities of designers, suppliers, constructors and regulators. The Government has an overall responsibility for ensuring the protection of the public health and the environment from radiation hazards that may occur in the development of nuclear energy.

1.3.2 Organisation and resources

KHNP is a sole nuclear power generating company in Korea. It has 4 divisions in the headquarters and 4 nuclear power sites, Radwaste Site Construction Office, Nuclear Engineering and Technology Institute, 26 hydro power plants and others.

Organization and human resources

The Safety and Technology Department of the KHNP headquarters includes the Radiation Safety Office, which consists of 16 persons and working for the safe management of radioactive waste and radiation safety.

Each NPP has a Radiation Safety Section with approximately 25 engineers tasked for the occupational radiation protection and for the treatment of radioactive waste generated from its nuclear facility. There are usually 6 staff members among them that work on the treatment and management of radioactive waste. As a collaborative company, Korea Plant Service and Engineering Co., Ltd. (KPS) supports the maintenance of radioactive waste treatment facilities. In addition, some radiation safety management service companies provide technical support of the radiation safety related activities.

For the nuclear safety review and decision making, the KHNP has the KHNP Nuclear Review Board (KNRB) at the headquarters and the Plant Nuclear Safety Committee (PNSC) at each nuclear plant.

The Radwaste Project Division in the KHNP headquarters is in charge of overall radioactive waste management projects. In addition, the Radwaste Site Construction Office has undertaken construction works for the LILW disposal facility. Nuclear Engineering and Technology Institute in the KHNP is in charge of R&D, technical support, management of RI waste from hospitals and industries, etc.

2. LEGAL FRAMEWORK

2.1 Primary Legislation and General Regulations

National laws related to the safety of spent fuel and radioactive waste management are the Atomic Energy Act (AEA), the Electricity Business Act (EBA), the Environmental Impact Assessment Act and others as shown in Table.2-1. All the provisions on nuclear safety regulation and radiation protection are contained in the AEA. The AEA was enacted as the main law concerning safety regulations for spent fuel and radioactive waste.

The laws concerning nuclear regulation, as shown in Figure 2-1, consist of 4 hierarchical levels: the AEA, the Enforcement Decree of the AEA, the Enforcement Regulations of the AEA (including regulations concerning technical standards of nuclear facilities, etc., and regulations concerning technical standards of radiation safety management), and the Notices of the MEST.

The AEA provides for basic and fundamental matters concerning the safety regulation. It includes

provisions on the Atomic Energy Commission (AEC), the Nuclear Safety Commission (NSC), the permit for construction and operation of radioactive waste disposal facilities, and others as shown in Table 2-1 and Figure 2-2. The Enforcement Decree of the AEA (the Presidential Decree) provides the particulars entrusted by the AEA, and the administrative particulars including the detailed procedures and methods, etc., necessary for the enforcement of the AEA.

The Enforcement Regulation of the AEA (the MEST Ordinances) provides the particulars including detailed procedures, the format of documents, and technical standards, as entrusted by the same Act and the same Decree. The Enforcement Regulations were divided into namely, the Enforcement Regulation of the Act, the Enforcement Regulation Concerning the Technical Standards of Reactor Facilities, etc., and the Enforcement Regulation Concerning the Technical Standards of Radiation Safety Management, etc. Lastly, the Notices of the MEST prescribe regulatory requirements, technical standards and guidelines, as entrusted by the same Act, the same Decree and the same Regulation.

Atomic Energy Act

The AEA prescribes basic matters on waste safety to be applied to radioactive waste management facilities, as follows:

- provisions on the permit for construction/operation of disposal facilities,
- provisions on step-by-step safety inspections related to installment and operations of radioactive waste management facilities,
- provisions on restrictions regarding disposal practices of radioactive wastes including prohibition of dumping into sea,
- provisions on the safe transport and package of radioactive waste, and
- provisions on the establishment and implementation of a basic policy and management program in order to manage radioactive wastes in a safe and efficient manner.

Enforcement Decree of the Atomic Energy Act

The Enforcement Decree of the AEA (Presidential Decree) specifies the detailed requirements for implementing basic matters on waste safety, referred to in the AEA, as follows:

- detailed provisions on application for the permit for construction/operation of radioactive waste management facilities and their alterations,
- detailed provisions on conditions of material accounting and security on specific nuclear materials in nuclear safeguard system,
- detailed provisions necessary for implementing the regulatory inspections of preoperational inspection, periodic inspection, disposal inspection, QA inspection applicable for radioactive management facilities, etc.,
- detailed provisions on the procedures and methods of clearance application of very low level radioactive waste,
- detailed provisions necessary for the safe transportation and packaging of radioactive materials, etc.

Table 2-1. Laws concerning nuclear regulation

Title	MAJOR CONTENTS	Competent Authorities	Remarks
Atomic Energy Act	Basic law on the nuclear safety regulations	MEST	-
Korea Institute of Nuclear Safety Act	Provides the establishment and operation of the Korea Institute of Nuclear Safety	MEST	-
Act on Physical Protection and Radiological Emergency	Establishes more effective system for physical protection of nuclear material and nuclear facilities, and provides legal and institutional basis for preventing radiological disaster and preparing countermeasures against radiological emergency	MEST	-
Nuclear Liability Act	Provides the procedures and the extent of compensation for any damages which an individual has suffered from a nuclear accident	MEST	-
Act on Indemnification Agreement for Nuclear Liability	Provides the particulars on a contract between the government and the operator to make up any compensation not covered by insurance	MEST	-
Electricity Business Act	Provides the basic system of electricity business	MKE	The safety regulations of the installation, maintenance, repair, operation, and security of radioactive waste maintenance facilities are to adhere to the Atomic Energy Act
Electric Source Development Promotion Act	Provides special cases relevant to the development of electric sources	MKE	Prior designation notice of nuclear site
Basic Law of Environmental Policy	Mother law of the environmental preservation policy	MOE	The AEA is entrusted with the particulars on measures to prevent radiological contamination
Act on Assessment of Impacts of Works on Environment, Traffic, Disasters, etc.	Provides the extent and procedures to assess environmental impact according to the Basic Law of Environmental Policy	MOE	Assessment of environmental impacts excluding radiological impacts
Framework Act on Fire Services	Provides for general matters on the prevention, precaution and the extinguishment of fires	MOPAS	The requirements for safety management of inflammables
Basic Act on Civil Defense	Provides for general matters on the civil defense system	MOPAS	Preparedness against disasters due to nuclear accidents is included in the basic civil defense plan
Basic Act on Management of Disasters and Safety	Provides for general matters on the control of man-made disasters	MOPAS	It prescribes corrective or complementary measures for violations in the implementation of the basic civil defense plan
Industrial Accident Compensation Insurance Act	Provides insurance to compensate workers in case of an industrial disaster	MOL	Nuclear workers are to be compensated in accordance with the compensation standards in the AEA.
Industrial Safety and Health Act	Provides for the preservation and enhancement of workers' health and safety	MOL	The AEA is entrusted with the particulars on radiological safety
Building Act	Provides for general matters on construction	MLTM	When the sites of disposal facilities have obtained prior approval, they are to be seen as having obtained construction permission in accordance with Building Act

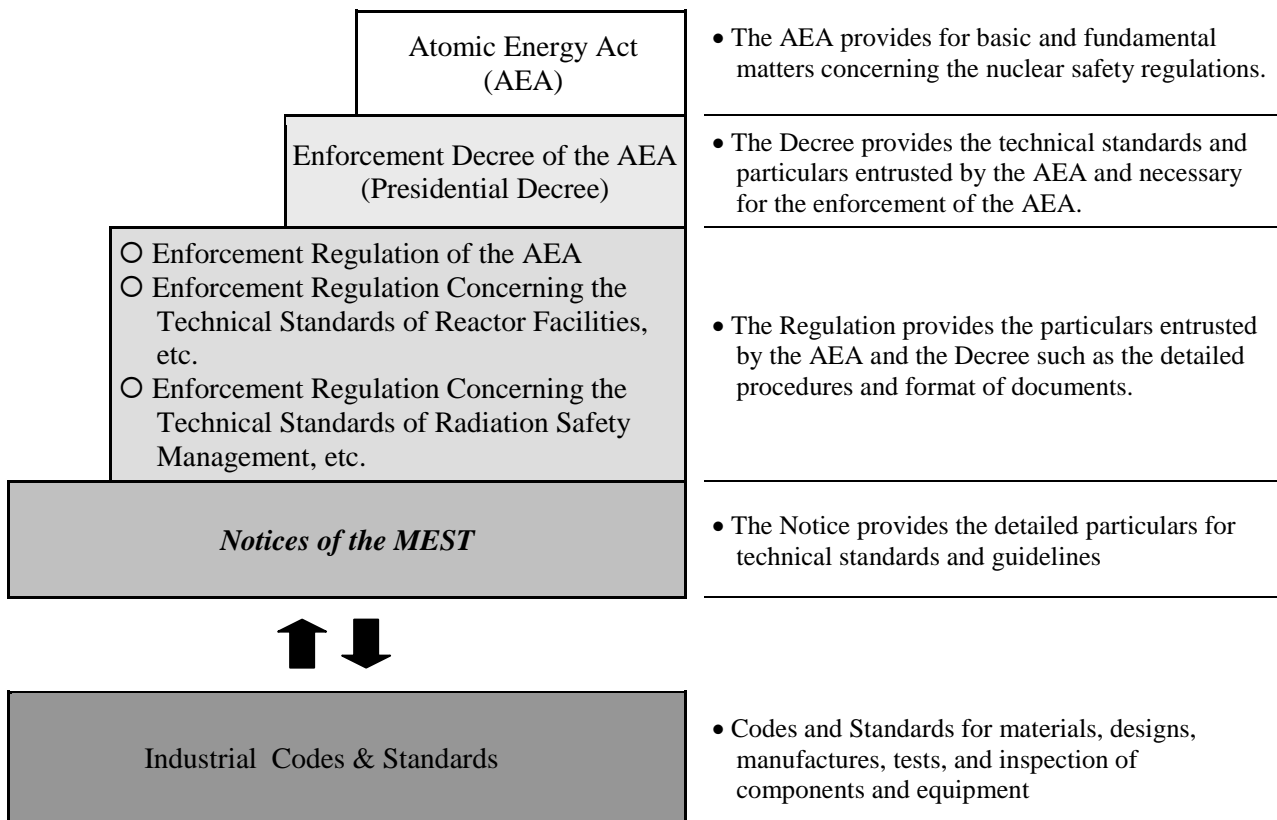


Figure 2-1. Legal hierarchy of the Atomic Energy Acts

2.2 Regulations concerning specific activities or facilities

The MEST Ordinance includes the Enforcement Regulations of the AEA, the Regulation Concerning the Technical Standards of Reactor Facilities, etc., and the Regulation Concerning the Technical Standards of Radiation Safety Management, etc., and prescribes detailed procedures and methods necessary for implementing the AEA and the Enforcement Decree of the AEA, and the detailed technical standards thereof.

- detailed provisions on detailed procedures and methods necessary for implementing the AEA and the Enforcement Decree of the AEA, and on the particulars about control and management of radioactive wastes, packaging and transportation of radioactive materials, etc., (Enforcement Regulations)
- detailed provisions on measures related to structure, equipment and performance of radioactive waste processing and storage facilities, etc. for reactor and related facilities, and nuclear fuel cycle facilities, (technical standards of reactors)
- detailed provisions on measures related to radioactive waste management plans in operation for reactor and related facilities, and nuclear fuel cycle facilities, (technical standards of reactors)
- detailed provisions on particulars about facilities, equipments and performance of near surface disposal, geological disposal, spent fuel management facilities, etc. (technical standards of radiation)
- provisions on performance standards for disposal facilities, for example, radiation monitoring, drainage, fire protection, and emergency power systems (technical standards of radiation)

2.2.1 Radioactive waste management

The Notices of the MEST present the detailed technical standards of radioactive waste management specified in the AEA, the Enforcement Decree of the AEA, and the Ordinance of the MEST. The principal notices related to radioactive waste management are listed as follows:

- Siting Criteria for the Low and Intermediate Level Radioactive Waste Repository
- Acceptance Criteria for the Low and Intermediate Level Radioactive Waste
- Radiological Protection Criteria for Long-term Safety on the Low and Intermediate Level Radioactive Waste Disposal
- Regulation on the Clearance Level of Radioactive Waste, etc.

2.3 Guidance on implementation

The Electricity Business Act (EBA) establishes a basic system regarding electricity business and stipulates basic information for the promotion of electricity business. The Enforcement Decree of the EBA, the Enforcement Regulations of the EBA, and the Ministry of Knowledge Economy (MKE) Notices provide necessary information for the implementation of standards and procedures entrusted by higher laws. As in Figure.2-2, the EBA system consists of 4 hierarchical levels; the EBA, the Enforcement Decree of the EBA, the Enforcement Regulations of the EBA, and the MKE Notice.

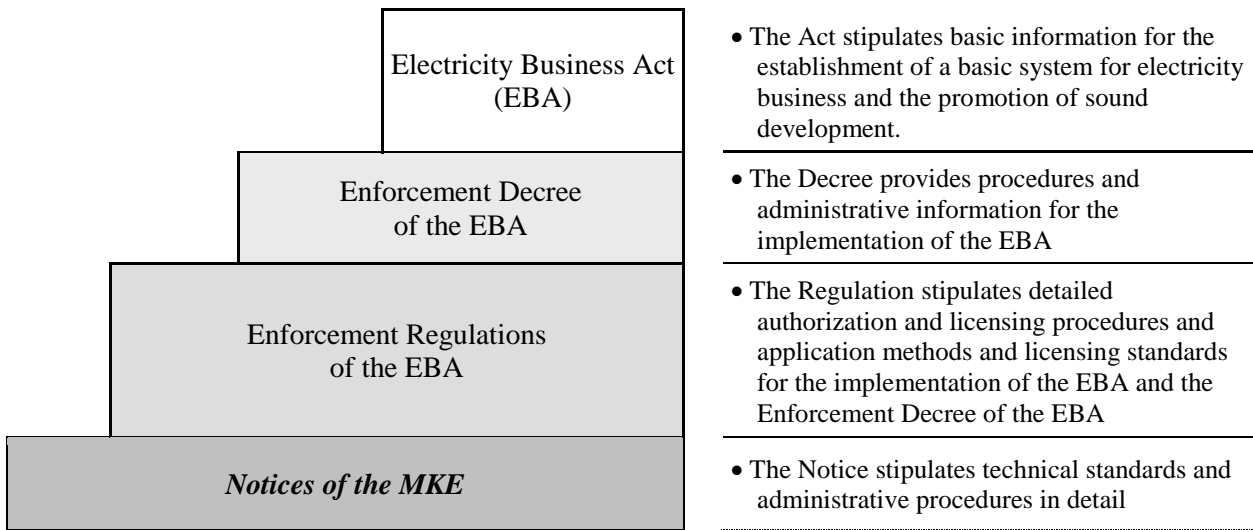


Figure 2-2. Legal hierarchy of the EBA System

Notices of the MKE

The MKE Notices provide detailed technical standards on the regulations in the EBA, Enforcement Decree of the EBA, and Enforcement Regulations of the EBA. As for MKE Notices related to radioactive waste, the Regulations on the Delivery and Cost of Radioactive Waste stipulate general requirements to deliver radioactive waste generated by non NPP operators to the Nuclear Waste Management Business Operator.

2.3.1 Radioactive waste management

The Radioactive Waste Management Act, which integrates and systematically determines all aspects of managing radioactive waste, was legislated and announced on March 28, 2008. The enactment of this law

has paved the way for the establishment of the Korea Radioactive Waste Management Organization and the Radioactive Waste Management Fund. The Act was (to be confirmed) expected to be put into force on January 1, 2009 and subordinate laws are currently being legislated.

3. WASTE MANAGEMENT STRATEGY AND CURRENT PRACTICE

3.1 Waste classification and quantities

The Atomic Energy Act (AEA) defines “Radioactive Waste” as radioactive materials or materials contaminated with radioactive materials which are the object of disposal, including spent fuel. The Enforcement Decree of the AEA defines high-level radioactive waste (HLW) as radioactive waste with radioactivity concentration and heat generation over the limit value specified by the MEST. In the strict sense, others than HLW belong to the LILW in accordance with the AEA. The limiting values on radioactivity and heat generation rate are specified in the MEST Notice No. 2008-31 (Standards on Radiation Protection, etc.) as follows:

- radioactivity : $\geq 4,000$ Bq/g for α -emitting radionuclide having a half life longer than 20 years
- heat generation rate : ≥ 2 kW/m³

Until 1998, waste classification based on IAEA Technical Report Series No. 101 (1970) had been applied. In August 1998, the criteria for radioactive waste classification was amended with a view to emphasizing radioactive waste disposal safety as above, in due regard to the IAEA revised classification system of IAEA Safety Series No. 111-G-1.1 (1994).

The AEA also defines the clearance level adopted from the “exempt waste” concept of the IAEA radioactive waste classification. The clearance levels in Korea are such that annual individual dose shall be below 0.01 mSv/y and the total collective dose below 1 person-Sv/y concurrently. These are identical to the levels specified in the IAEA Safety Series No. 115 (1996).

Nuclear power plants currently in operation have their own gaseous, liquid, and solid waste treatment facilities and on-site storage facilities to ensure the safe management of radioactive waste generated in the process of operation. The RI waste generated from domestic RI users and research institutes is collected and stored at NETEC of KHNP.

Low and intermediate level radioactive waste types are as follows:

- Power plants: dry active waste, spent resin, spent filter, concentrated waste
- Non-power plant sources (RI waste): dry active waste (combustible or non-combustible), hepatitis waste, organic liquid waste, spent sealed source, and spent filter.

All radioactive wastes are to be stored in on-site temporary storage until the operation of a disposal facility. The amount of radioactive waste being stored by the end of 2009 is 86,757 drums from power plants. The total capacity of temporary storages in NPP sites are 99,900 drums and the cumulated radioactive wastes stored in each site are shown in Table 3-1(A).

In order to implement the fundamental principles approved at the 253rd meeting of the AEC, the Government of the Republic of Korea decided upon the construction of a disposal facility that could dispose of 100,000 drums (hereafter, “drums” means “200 liter-drum equivalents” unless otherwise mentioned) for the first stage and that would ultimately reach a total of 800,000 drums after gradual expansion. As for the disposal method, it was decided to adopt a near-surface repository or a rock cavern repository depending on site conditions.

To enhance public acceptance of the LILW disposal facility, an Act titled “Special Act on Support for Areas Hosting Low and Intermediate Level Radioactive Waste Disposal Facility” were legislated and announced on March 31, 2005. As stipulated in the Special Act, the MKE has implemented the entire site selection process fairly and transparently by operating the Site Selection Committee (SSC), which consists of 17 civilian experts from diverse fields, proceeded openly with the host area selection plan, site investigation results, and site selection process and held open forums and discussions for local residents. After the results of local referendums held in the regions whose local governments had applied to host disposal facility in accordance with the site selection procedures, the city of Gyeongju was selected as the final candidate site. The area of this final candidate site is large enough to accommodate a total of 800,000 drums of the LILW, and, as the first stage of construction, a rock cavern type of repository accommodating upto 100,000 drums was chosen. The disposal facility to be constructed in Gyeongju was named the “Wolsong Low and Intermediate Level Radioactive Waste Disposal Center”.

Table 3-1(A). Status of radioactive waste storage in NPPs (As of Dec. 2009)

Nuclear Power Stations		Storage capacity (drum)	Cumulative Amount (drum)
Location	Number of Reactors		
Kori	4	50,200	40,387
Yonggwang	6	23,300	20,776
Ulchin	6	17,400	16,290
Wolsong	4	9,000	9,304
Total		99,900	86,757

Whether to directly dispose or recycle the spent fuel has not yet been decided.. Because the 253rd meeting of AEC(Atomic Energy Commission) stipulated that national policy for spent fuel management will be decided later in consideration of the domestic and international technology development, spent fuel is being stored at a reactor site under the KHNP's responsibility.

The existing storage capacity as of December 2009 are 13,532 MTU. Active nuclear energy utilization causes a significant spent fuel accumulation problem. The cumulative amount of spent fuel is about 10,761 ton as of Dec. 2009, and is expected to increase up to 20,000 ton by 2020. Of those, CANDU spent fuel accounts for more than 50% of total amounts.

For CANDU reactors, spent fuels have been stored in a dry concrete silo since 1991. During the past years, 300 silos were constructed and 3,049 ton of spent fuels are stored now. CANDU spent fuel will be stored at the new dry storage facility, MACSTOR/KN-400, from 2010. One storage module of this system can accommodate 24,000 CANDU spent fuel assemblies, which are equivalent to the amount of spent fuel generated from 4 CANDU reactors (700 MWe each) for about 1.2 years.

For PWRs, spent fuels are now stored at NPP pool, but all storage pools are expected to reach their full capacity in several years. To expand the insufficient storage space at plant sites, re-racking and transshipment to neighboring plants are utilized as a short-term solution until national spent fuel management policy is decided. The amount of spent fuels stored at each reactor site as of Dec. 2009 is described in Table 3-1(B).

(overlapped with above)

Table 3-1(B). Status of spent nuclear fuel (As of Dec. 2009)

Nuclear Power Stations		Storage capacity (MTU)	Cumulative Amount (MTU)
Location	Number of Reactors		
Kori	4	2,253	1,762
Yonggwang	6	2,686	1,704
Ulchin	6	2,328	1,401
Wolsong	4	6,265	5,894
Total		13,532	10,761

3.2 Waste management strategy

3.2.1 Nuclear power plants

Gaseous radioactive waste management

Gaseous radioactive waste is mainly generated from the degassing of the primary system and ventilation systems for the radiation controlled area in NPPs. The gaseous waste from the primary system shall be treated by gas decay tank or charcoal delay bed to reduce radioactivity and to release it into the atmosphere through a radiation monitor. Gaseous waste from the building ventilation system is also to be exhausted through a high-efficiency particulate filter and a charcoal filter under continuous monitoring into the environment.

Liquid radioactive waste management

Liquid radioactive waste is mainly generated from the cleanup and maintenance process of reactor coolant and related systems containing radioactivity. In general, liquid radioactive waste is treated with evaporators, demineralizers, and/or filters. The effluent is either reused in the plant systems or released to the sea after monitoring. The Korean Standard Nuclear Power Plant has a selective ion exchange system instead of an evaporator to increase efficiency in the treatment of liquid radioactive waste.

Solid radioactive waste management

Most solid radioactive waste consists of dry active waste (DAW) and secondary process waste. The DAW is generated during maintenance and repair of contaminated systems and includes items such as used parts, papers, used clothes, gloves, shoes, etc. Secondary waste is generated from the liquid and gaseous radioactive waste treatment system and includes concentrated wastes from evaporators, spent resin from demineralizers, and spent filters from liquid purification systems.

The DAW is compressed by a conventional compactor (capacity: 10 tonne) into drums. Additional volume reduction of the DAW can be done with a super-compactor (capacity: 2000 tonne). Solidification by cement, which was commonly applied in the past, is not used any longer. Instead, the concentrated waste is now dried and stabilized by paraffin in drums and spent resin is kept in a high-integrated or equivalent container, after drying in the spent resin drying facility. Spent filters are stored in a shielding container.

3.2.2 Research facilities

The KAERI has several facilities where radioactive materials are handled, such as HANARO research reactor, post irradiation examination facility (PIEF), radioisotope production facility (RIPF), irradiated material examination facility (IMEF), nuclear fuel fabrication facility for research reactor, and other laboratories. Additionally, it operates a radioactive waste treatment facility for the treatment and storage of

radioactive waste.

Gaseous radioactive waste management

In every facility, a ventilation system is equipped with filters to treat off-gas before its release to the atmosphere. The stacks of such facilities, that is, the final outlets, have a continuous air monitor. When the radioactivity concentration in off-gas exceeds the internal guidelines, the operation of the ventilation system should be stopped to keep the public dose rate lower than the target limits.

Liquid radioactive waste management

Liquid waste generated from each facility of the KAERI is transferred through an underground pipeline to a collection tank of the radioactive waste treatment facility, and all the wastes are evaporated and the resulting condensate is processed in a solar evaporation facility. No liquid waste is directly discharged to the environment.

Solid radioactive waste management

Solid radioactive waste, generated from each facility at KAERI, except spent fuels, is transferred to the radioactive waste treatment and storage facilities. Solid radioactive waste with a higher radiation dose rate than the internal guidelines is packed in 50L stainless steel drums, and kept in a concrete monolith with adequate shielding capacity. Solid radioactive waste with a radiation dose rate below the internal guidelines is packed in 200L steel drums with compaction of the waste, and kept in the storage facility.

3.3 Waste Management Issues at national level

For the enhancement of public acceptance on nuclear industry, the government and Korea Hydro & Nuclear Co. Ltd.(KHNP) carried out several small research projects to gather the public opinion. NGOs, expert groups from nuclear industry, and social science are discussing to propose the national strategy for the long-term management of spent fuels.

3.4 Research and Development

3.4.1 Research infrastructure

The MOST has the overall responsibility for the HLW disposal research and development as well as the regulatory and licensing of the disposal facility. And the KAERI is performing basic R&D programs for the HLW disposal. The long-term HLW disposal study started in 1997 and the third phase of R&D study ended in February, 2007. Now, the fourth phase of R&D study is underway. The Korean reference disposal system to accommodate all kinds of wastes from advanced fuel cycle will be developed. And key technologies developed in the third phase of R&D study will be verified. The annual budget for this R&D program is about 6 million dollars. KAERI has the KAERI Underground Research Tunnel (KURT), an infrastructure for the validation of the disposal technology. The KURT tour program is organized, and open it to all people who are interested in the KURT.

3.4.2 Contents of R&D plans

The major current research topics are as follows;

- Development of A-KRS (Korean Repository System)

The objective of the development of A-KRS is to assess the technical feasibility of the repository system developed under the given geologic environment and to improve the performance of KRS to accept the HLW from the AFC system and enhance the disposal density.

- Total System Performance Assessment (TSPA) study

The objective TSPA study is to analyze the post closure safety of the developed repository system. The major topics of this study are; scenario development, probability and consequence modelling, development of safety assessment methodologies, and implementation of QA program.

□ Geo-environment Characterization

In this research project, the characterization and defining of the reference geological environment will be made in consideration of long-term geological stability such as neotectonics, volcanism, seismic effect, uplift/subsidence, and erosion effect. The preferred conditions for a deep geologic repository will be suggested based on the results of this study.

□ Demonstration of KRS Performance

The experimental investigation of the Korean disposal system performance and establishment of in-situ experimental techniques will be carried out in this study. And radionuclide behavior under the deep geological condition will also be investigated. Several research topics such as an engineered scale THM experiment, solute migration experiment, and measurement of input parameters for the TSPA will be covered in the KURT.

3.5 Financing of Radioactive Waste Management

3.5.1 Framework and responsibilities

Nuclear power plants

According to the EBA, the NPP operator should deposit the cost of plant decommissioning, disposal of LILW and spent fuel management as a yearly basis. The KHNP has accumulated these costs as an in-house liability since 1983.

In accordance with Notices of the MKE, as an in-house liability, the initially estimated cost is calculated, then estimated cost at the time of dismantling or prospective disposal is calculated to reflect the inflation rate and converted into the current value, and the value of the annual interests are conserved. In accordance with such calculation standards, nuclear power generation licensees supply the reserve funds for each category to be calculated. The MKE recalculates and announces the calculated variables every 5 years.

According to the Radioactive Waste Management Act legislated in 2008, the in-house liability are scheduled to be converted into the Radioactive Waste Management Fund and managed starting on January 1, 2009. According to the Radioactive Waste Management Act, when those who have generated radioactive waste transfer the cost of maintaining radioactive waste to the established(already established?) Korea Radioactive Waste Management Corporation (KRMC), the Corporation will pay this maintenance cost to the fund. However, as for the spent fuel generated by nuclear power generation licensees, , the cost of managing such fuel will be imposed on nuclear power generation licensees to smoothly implement projects related to the management of spent fuel as the spent fuel management costs and reverted to the fund.

HANARO research reactor

All the facilities for the spent fuel management, radioactive waste treatment and waste storage at KAERI are in operation with the organizational project fund provided by the government.

Nuclear fuel fabrication facility

Under the EBA, the radioactive waste generator shall pay radioactive waste management expenses at the delivery point of radioactive waste to the disposal site. In order to reduce the economic burden to pay the

increased waste management at the time, KNF has been quarterly reserving expenses for radioactive waste.

Radioactive waste management facility

Under the EBA, the radioactive waste generator shall pay radioactive waste management expenses at the delivery point of radioactive waste to the disposal site. In order to reduce the economic burden to pay the increased waste management at the time, KNF has been quarterly reserving expenses for radioactive waste.

3.5.2 Status of financing schemes

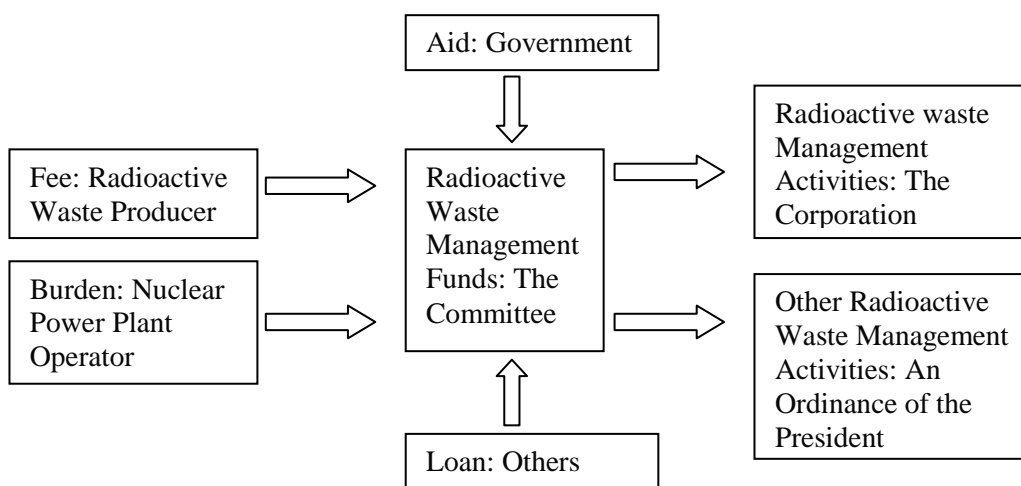


Fig. 3-1 Korea radioactive waste management financing structure

4. DECOMMISSIONING STRATEGY AND CURRENT PRACTICE

4.1 Decommissioning strategy

Design and construction of facilities

All radioactive waste management facilities, except for the radioactive waste disposal facility, shall be designed in consideration of decommissioning.

Minimization of waste

Minimization of waste generation has been an important principle for the whole stage of decommissioning.

Radiation Safety

In the decommissioning of the KRR-1 and -2 and uranium conversion facility, the same regulations for the operation of the corresponding facilities, described in Article 24 of the Joint convention, are applied to the radiation protection and safety. In the decommissioning plan of the facilities, the status of facilities, radiological conditions, and anticipated waste are considered. Required human resource are described and dose rate of workers at normal and abnormal conditions, and radiation protection measures were evaluated in accordance with the MEST radiation safety regulations. At the actual worksite where the decommissioning works take place, the radiation protection is controlled according to the detailed plan specific to working conditions.

The regulations applied to the decommissioning site are Notices on the Standards for Radiation Protection, etc., the Regulation on the Packaging and Transport of Radioactive Materials, etc., the Regulations on Preparation, etc. of Radiological Environmental Report of Nuclear Utilization Facilities, and the Regulations on the Environmental Radiation Survey and Impact Analysis in the Vicinity of Nuclear Facilities.

4.2 Status of decommissioning projects

KRR-1 and 2

Radioactive wastes from the decommissioning of KRR-1 and 2 were classified according to their characteristics and radioactivity levels, packed into 200-liter drums or 4 m³ containers and stored in the reactor hall of the KRR-2. The inventory of radioactive waste generated from KRR-1 and 2 decommissioning site is given in Table 4-1. The major radionuclides in the activated waste are ⁶⁰Co and ¹⁵²Eu, and are ⁶⁰Co and ¹³⁷Cs in the case of the contaminated waste.

Table 4-1. Inventory of radioactive waste stored at the KRR-1 and 2 decommissioning site

(as of December 2007)

Facility	Inventory [drum]	Major radionuclides	Total activity estimated [TBq]
Temporary storage building	1044	⁶⁰ Co, ¹³⁷ Cs, ¹⁵² Eu, etc.	6.1E-01

Uranium conversion facility

Radioactive waste from the decommissioning of the uranium conversion facility (UCF) is stored in temporary storage building in the conversion facility. The inventory of radioactive waste generated from the UCF decommissioning site is given in Table 4-2. All the wastes are contaminated only with natural uranium.

Table 4-2. Inventory of radioactive waste stored at the uranium conversion facility decommissioning site

(as of December 2007)

Facility	Inventory [drum]	Major radionuclide	Total activity estimated [TBq]
Temporary storage building	303	natural uranium	7.9E-03

Data Management

Under the Enforcement Regulation of the AEA, records of the operation of the nuclear facilities are to be kept until the decommissioning of the facilities for the application of the records to the planning and implementing of the decommissioning. The records include documents related to the reactor design and construction, data on radiation protection, abnormal operation conditions and their remedial works, etc.

Information related to the decommissioning of the research reactors and the uranium conversion facility has been collected by the Division of Decontamination and Decommissioning Technology Development at KAERI. The information includes data concerning the condition and radiological state of the facilities, the nature and duration of each activity, the input of the workforce and equipment for each activity involved, the radiation dose to each worker, inventory of each class of radioactive waste generated and major radionuclides, the amount of liquid waste treated, and others. This information is to be preserved for a period as specified in the decommissioning plan.

The database system, named DECOMMIS, was developed and has been operated to collect all of the relevant information related to the decommissioning waste, including its generation, decontamination, packing, and storage. It enables to manage the decommissioning waste in a systematic way and to report safety information to the WACID, which is a DB system developed and operated by the KINS for managing the nationwide safety information on radioactive waste management.

4.3 Decommissioning issues at national level

KRR-1

The dismantling of the KRR-1 reactor was suspended because of the strong recommendation for setting up a monument from KRR-1 reactor by the old seniors of the nuclear engineering fields and the schedule of the dismantling was modified to firstly dismantle the auxiliary facilities, consisted of experiment laboratories, 4 small sized lead hot cells, steel hot cell, source storage room including ventilation duct system. After these dismantling works were done, the equipment in some yard facilities were dismantled and the facilities were decontaminated. These facilities are; a resin regeneration facility, a newly constructed tank system for gathering liquid waste from KRR-1, an old liquid waste treatment facilities with tanks and pumps for KRR-1, a series of the liquid waste tank for KRR-2.

Persistent Activity

The decommissioning of the nuclear facilities requires the high technologies such as remote operation and radioactivity evaluation which was developed and experience gained in the course of the decommissioning of facilities. These developed technologies and experience gained from the decommissioning can be utilized for a new decommissioning project of the large commercial nuclear facilities in the future.

But, even though the decommissioning of nuclear facilities, eg., KRR-1, KRR-2 and UCP was advanced close to the final stage, there is no additional decommissioning plan. There was concern that the cumulated technologies and experience can be faded because subsequent decommissioning projects were not identified.

4.4 Research and development

4.4.1 Research Infrastructure

It is recommended to refer to 4.5.1 section

4.4.2 Contents of R&D plans

The project management technologies, including manpower control, waste tracing and radiation protection were developed. Besides the projects of decommissioning, development of new technologies was carried out and it covered developments of a concrete sludge treatment, a melting treatment of metallic waste by a high frequency induction furnace, and a bio-denitration process of lagoon sludge as an alternative process

of the thermal treatment process, which is now adopted.

4.5 Financing

4.5.1 Framework and responsibilities

Nuclear power plants

There is no power reactor yet that requires decommissioning and therefore no specific organization for the decommissioning of NPP exists in Korea. The NPP operators plan to make use of an organization consisting of operating plant staff members for future decommissioning of plants.

KRR-1 & 2 and uranium conversion facility

The KAERI, as a responsible operator of the facilities, has carried out the projects for decommissioning of KRR-1, 2 and the UCF, along with development of related technologies and demonstration studies. To do this, the KAERI set up the “Division of Decontamination and Decommissioning Technology Development”, comprised of 20 members. Additionally, retirees of the KAERI with ample experience in reactor operation have been tasked with the safe dismantling of the reactor

4.5.2 Status of financing schemes

Nuclear power plants

The decommissioning cost of NPP(Nuclear Power Plant) is inevitable for the nuclear electricity business. Due to the uncertainties about the future cash flow and management methods, the cost should be reliably estimated based on reasonable and supportable assumptions. According to the EBA(Electricity Business Act), the NPP operator should determine the cost of plant decommissioning, disposal of LILW(Low and Intermediate Level Radioactive Waste) and spent fuel generated in the process of NPP operation every year. The KHNP(Korea Hydro & Nuclear Power Co., Ltd.) has accumulated these costs as an in-house liability since 1983. Recently, the statement of financial accounting standard was revised to recognize a liability for asset retirement as a present value of decommissioning costs. The EBA adapted the same methodology; thus decommissioning and disposal cost should be recognized as a present value and an annual interest added up every year from 2005. The Notice of MOCIE(Ministry of Commerce, Industry and Energy) stated various parameters such as assumption cost, inflation rate, interest rate and etc. to estimate discounted cash flow in accordance with the revised EBA. The KHNP has recognized the post-NPP disposal reserve to abide by the regulation with audit conducted by an independent auditor.

KRR-1 & 2 and uranium conversion facility

KRR-1 and 2 and the UCF were constructed and had been operated by the KAERI as funded by the Government of the Republic of Korea. As such, the Government provides all financial resources required for safe decommissioning of the facilities.